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ANALYSIS OF NULL RESULTS OF HAMMAR EXPERIMENT BY CLASSICAL MECHANICS WITHOUT SPECIAL THEORY OF RELATIVITY

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ABSTRACT

In optics interferometers are used for precision measurements. In interferometry two waves of light are superimposed to generate interference fringes. The interference pattern is observed and analyzed to measure physical process. Gustaf Wilhelm Hammar conducted an experiment in the year 1935 to test aether drag hypothesis. The null results of this experiment were interpreted in consistent with special theory of relativity. Hammar used common path interferometer and observed the changes in interference fringes due to motion of earth. The present work describes that when there is no aether and no medium drags the light in its direction of motion than what will be the behaviour of light.The analysis has been made according to classical mechanics keeping in view Huygen's principle by tracking the pathways of both the rays of light.It is established that speed of light is independent of velocity of any object,apparatus or any observer and there is no effect of motion of earth.The null results of Hoek's experiment and Hammar experiment are in consistent with classical mechanics

KEYWORDS: Interference Fringe, Rays of Light, Classical Mechanics

INTRODUCTION

The null results of various experiments such as Michelson and Morley experiment, Kennedy-Thorndike experiment, Michelson-Gale-Pearson experiment, Hammar experiment were considered in consistent with the special theory of relativity. All these experiments are conducted on the wave nature of light. Wavefront of light plays very important role in these experiments. In interferometers two beams of light are derived from a single beam/source for generating fringes and fringeshift are observed due to path difference. Failure of these experiments led to the postulates of special theory of relativity and later confirmed the STR. The results of these experiments could not be explained by classical mechanics. In this paper it is demonstrated that null results of Hammar experiment can easily be explained by classical mechanics without postulates of special theory of relativity.

Experiment

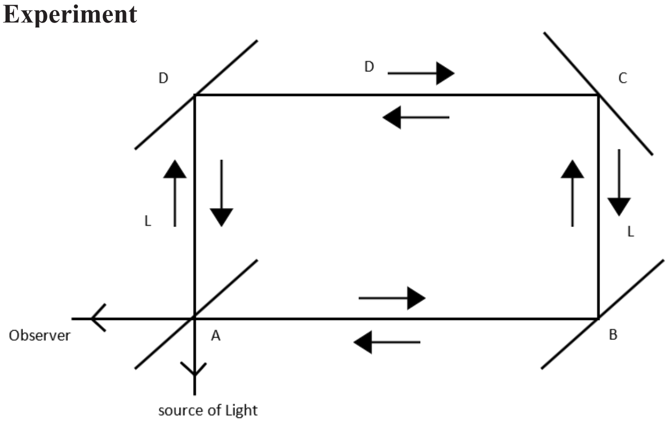

Fig I Set up of Hammar Experiment

By using Common path interferometer Hammar used a half-silvered mirror A and divided a ray of light in to two rays. One ray was sent in the transverse direction in to a heavy walled steel pipe terminated with lead plugs. The ray was reflected by mirror D and sent in to longitudinal direction to another mirror C at the end of pipe. After reflection from mirror it was sent in the transverse direction to the mirror B. From B it travelled back to A in the longitudinal direction. The otherpart of ray travelled the same path in the opposite direction. The experiment was conducted on the top of a high hill near Moscow and made many observation with the apparatus turned in all direction during day light hours. No fringe shift was observed and confirmed the special theory of relativity. The results of Hammar experiment are analyzed by classical mechanics.

Ray I: A parallel wavefront of light strikes the semi-silvered mirror at A and Ray I goes towards mirror D but by the time t_1 light reaches mirror D, mirror D will move to a new position moving with velocity v of earth travelling distance vt_1. The ray I will travel the distance $(L + vt_1)$ where L is the distance A to D. Light will travel with velocity c in time t1 covering distance ct_1

therefore $L + vt_1 = ct_1$

$$ct_1 - vt_1 = L$$

$$t_1 (c - v) = L$$

$$t_1 = \frac{L}{c-v} \quad \text{............ (i)}$$

This ray will reach to the mirror C by travelling the distance $(D - 2vt_1)$ with velocity $(c + v)$ where D is longitudinal distance D to C and after reflection from mirror C it will reach to mirror B by travelling the distance $(L + vt_1)$ with velocity c there after it will reach at A travelling distance D with velocity $(c - v)$ The Actual path traversed by ray I is shown in Fig II.

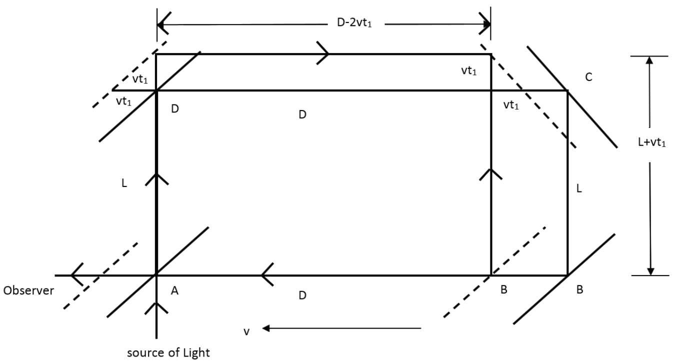

Fig II Simplified diagram of pathway of ray I

The total distance travelled by the ray I will be (L + vt_1) + (D – $2vt_1$) + (L + vt_1) + D

Let the total time to complete this path by ray I be t

therefore $t = \frac{L+vt_1}{C} + \frac{D-2vt_1}{C+V} + \frac{L+vt_1}{C} + \frac{D}{C-V}$

$$= \frac{2(L+vt_1)}{c} + \frac{D-2vt_1}{c+v} + \frac{D}{c-v}$$

$$= \frac{2(L+vt_1)}{C} + \frac{Dc-Dv-2cvt_1+2v^2t_1+Dc+Dv}{(C+V)(C-V)}$$

$$= \frac{2(L+vt_1)}{C} + \frac{2\,Dc-2vt_1\,(c-v)}{(c+v)(c-v)}$$

$$= \frac{2\left(L+\frac{v\times L}{c-v}\right)}{C} + \frac{2\,Dc-2V\times\frac{L}{c-v)}(c-v)}{(c+v)(c-v)}$$ By putting the value of t_1 from equation (i)

$$= \frac{2\,LC-2\,LV+2\,LV}{C\,(C-V)} + \frac{2\,Dc-2Lv}{(c+v)(c-v)}$$

$$= \frac{2\,L}{(C-V)} + \frac{2Dc-2\,Lv}{(C+V)(C-V)}$$

$$= \frac{2\,Lc+2Lv+2Dc-2Lv}{(c^2-v^2)}$$

$$= \frac{2\,Lc}{c^2-v^2} + \frac{2\,Dc}{c^2-v^2}$$

$$= \boxed{\frac{2L}{C}\frac{1}{1-\frac{v^2}{C^2}} + \frac{2D}{C}\frac{1}{1-\frac{v^2}{C^2}}} \quad \ldots\ldots\ldots\ldots\ldots \text{I}$$

Ray II: The ray II after reflection at semi-silvered mirror A will go towards mirror B travelling distance D with velocity (c + v) and after reflection at the mirror B it will go perpendicularly towards mirror c but by the time t_2 it reaches at mirror C, mirror C will move to a new position travelling with velocity v of earth hence ray II will strike the mirror travelling distance (L – vt_2) with velocity c covering distance ct_2 as shown in Fig III

therefore $ct_2 = L - vt_2$

$t_2\,(c + v) = L$

$t_2 = \frac{L}{c+v}$ …………… (i)

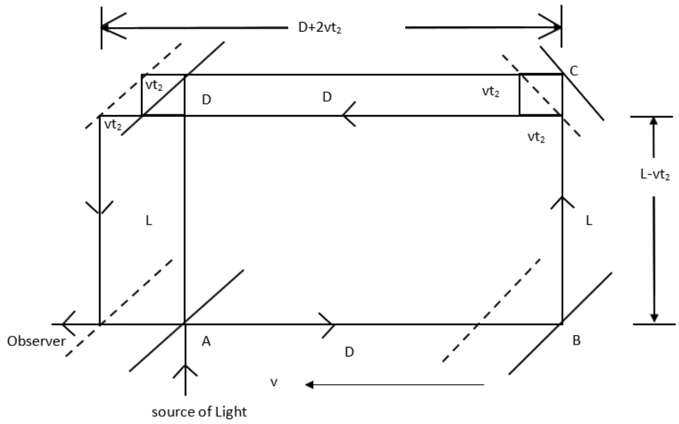

Fig III simplified diagram of pathway of ray II

Let the total time to complete this path by Ray II be t

therefore $t = \frac{D}{(c+v)} + \frac{L-vt_2}{c} + \frac{D+2vt_2}{(c-v)} + \frac{L-vt_2}{c}$

$$= \frac{2\,(L-vt_2)}{c} + \frac{D}{(c+v)} + \frac{D+2vt_2}{(c-v)}$$

$$= \frac{2\,(L-vt_2)}{c} + \frac{Dc-Dv+Dc+Dv+2\,cv\,t_2+2v^2t_2}{(c+v)(c-v)}$$

$$= \frac{2\,(L-vt_2)}{c} + \frac{2\,DC+2vt_2\,(c+v)}{(c+v)(c-v)}$$

$$= \frac{2\left(L-v\times\frac{L}{c+v}\right)}{c} + \frac{2\,Dc+2\,v\times\frac{L}{c+v}(c+v)}{(c+v)(c-v)}$$ By putting the value of t_2 from equation (i)

$$= \frac{2\,(Lc+Lv-Lv)}{c\,(c+v)} + \frac{2\,Dc+2\,Lv}{(c+v)(c-v)}$$

$$= \frac{2\,L}{(c+v)} + \frac{2\,Dc+2\,Lv}{(c+v)(c-v)}$$

$$= \frac{2\,Lc-2\,Lv+2\,Dc+2\,Lv}{c^2-v^2}$$

$$= \frac{2\,Lc}{c^2-v^2} + \frac{2\,Dc}{c^2-v^2}$$

$$= \boxed{\frac{2L}{C}\frac{1}{1-\frac{v^2}{C^2}} + \frac{2D}{C}\frac{1}{1-\frac{v^2}{C^2}}} \quad \ldots\ldots\ldots\ldots\ldots\ldots \text{II}$$

As per equation I and II both the rays of light are taking equal time after traversing different paths in opposite direction and no path difference is involved due to motion of earth.

Let us consider the case when interferometer is rotated at 90^0 angle when earth will be moving in perpendicular direction as shown in Fig IV

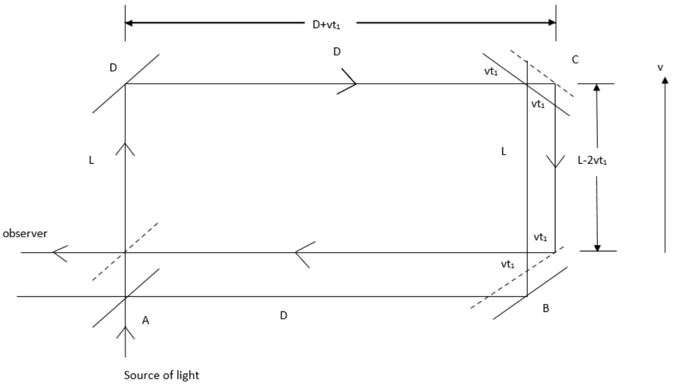

Fig IV Diagram of pathway of ray I

Ray I : The ray I will go in transverse direction towards mirror D with velocity (c – v) and after reflection from mirror D it will go towards mirror C but by the time t_1 light reaches mirror C it will move to a new position with velocity v of earth hence distance covered by light will be ($D + vt_1$) Light travelling with velocity c in time t_1 will cover the distance ct_1

therefore $ct_1 = D + vt_1$

$$t_1 (c - v) = D$$

$$t_1 = \frac{D}{(c-v)} \quad \ldots\ldots\ldots\ldots\ldots\ldots \text{(i)}$$

After reflection from mirror C the ray I will reach mirror B covering distance ($L - 2vt_1$)with velocity (c + v) and at last it will go towards original semi-silvered mirror A covering distance ($D + vt_1$)with velocity c. The total distance covered by ray I will be.

$L + (D + vt_1) + (L - 2vt_1) + (D + vt_1)$

Let the total time to complete the journey by ray I be t

therefore $t = \frac{L}{(c-v)} + \frac{D+vt_1}{c} + \frac{L-2vt_1}{(c+v)} + \frac{D+vt_1}{c}$

$$= \frac{L}{(c-v)} + \frac{L-2vt_1}{(c+v)} + \frac{2\,(D+vt_1)}{c}$$

$$= \frac{L}{(c-v)} + \frac{L-\frac{2v\times D}{c-v}}{c+v} + \frac{2D + 2v\frac{\times D}{c-v}}{c}$$ By putting the value of t_1 from equation (i)

$$= \frac{L}{(c-v)} + \frac{Lc-Lv-2Dv}{(c+v)(c-v)} + \frac{2Dc-2Dv+2Dv}{c\,(c-v)}$$

$$= \frac{L}{(c-v)} + \frac{Lc-Lv-2Dv}{(c+v)(c-v)} + \frac{2D}{(c-v)}$$

$$= \frac{Lc+Lv+Lc-Lv-2Dv+2Dc+2Dv}{(c+v)(c-v)}$$

$$= \frac{2Lc+2Dc}{c^2-v^2}$$

$$= \frac{2Lc}{c^2-v^2} + \frac{2Dc}{c^2-v^2}$$

$$= \boxed{\frac{2L}{C}\,\frac{1}{1-\frac{v^2}{C^2}} + \frac{2D}{C}\,\frac{1}{1-\frac{v^2}{C^2}}} \quad \ldots\ldots\ldots\ldots\ldots\ldots \text{I}$$

Ray II: The ray II after reflection from mirror A will go towards mirror B but by the time t_2 light reaches mirror B the mirror will be in a new position travelling with velocity v of earth and light travelling with velocity c in time t_2 will cover the distance ct_2 and the distance covered by ray will be ($D - vt_2$)

therefore $ct_2 = D - vt_2$

$$t_2\,(c + v) = D$$

$$t_2 = \frac{D}{(c+v)} \quad \ldots\ldots\ldots\ldots\ldots\ldots \text{(i)}$$

as shown in Fig V.

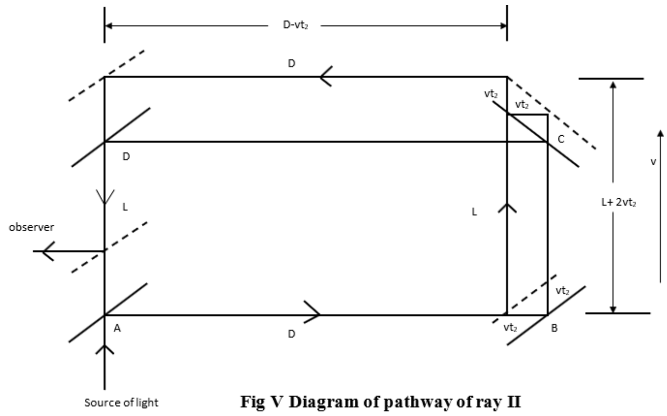

Fig V Diagram of pathway of ray II

After reflection from mirror B Ray II will go towards mirror C with velocity (c–v) covering distance $L + 2vt_2$ and after reflection from mirror C it will reach mirror D covering distance of ($D - vt_2$) with velocity c and at last it will reach at original point at mirror A after reflection from mirror D covering the distance L with velocity (c + v)

The total distance covered by ray II will be $(D - vt_2) + (L + 2vt_2) + (D - vt_2) + L$

Let the total time to complete the journey by ray II be t

therefore $t = \frac{D-vt_2}{c} + \frac{L+2vt_2}{(c-v)} + \frac{D-vt_2}{c} + \frac{L}{(c+v)}$

$$= \frac{L}{(c+v)} + \frac{2D-2vt_2}{c} + \frac{L+2vt_2}{(c-v)}$$

$$= \frac{L}{(c+v)} + \frac{2D-2v\times\frac{D}{(c+v)}}{c} + \frac{L+2\,v\times\frac{D}{(c+v)}}{(c-v)}$$ By putting the value of t_2 from equation (i)

$$= \frac{L}{c+v} + \frac{2Dc+2Dv-2Dv}{c\,(c+v)} + \frac{Lc+Lv+2Dv}{(c+v)(c-v)}$$

$$= \frac{L}{c+v} + \frac{2D}{c+v} + \frac{LC+Lv+2Dv}{(c+v)(c-v)}$$

$$= \frac{Lc-Lv+2Dc-2Dv+Lc+Lv+2Dv}{(c+v)(c-v)}$$

$$= \frac{2Lc + 2Dc}{(c^2-v^2)}$$

$$= \frac{2Lc}{(c^2-v^2)} + \frac{2Dc}{(c^2-v^2)}$$

$$= \boxed{\frac{2L}{C}\,\frac{1}{1-\frac{v^2}{C^2}} + \frac{2D}{C}\,\frac{1}{1-\frac{v^2}{C^2}}} \quad \ldots\ldots\ldots\ldots\ldots\ldots \text{II}$$

As evident from equation I and II both the rays of light will be

taking equal time hence no path difference is involved on the rotation of interferometer at 90^0 angle.

RESULTS AND DISCUSSION

No path difference will be involved between the rays spllited in to two parts from the semi-silvered mirror and reunited at the same point after traversing different paths and there is no effect of motion of earth. No fringe shift can be observed by rotating the interferometer in any direction. The same analogy may be applied on the Michelson-Gale-Pearson experiment and other experiments are also to be analyzed. Fizeau experiment also does not violate classical mechanics. The result of this experiment establishes the fact that no medium can drag the light in its direction of motion. Medium can only retard the speed of light according to its refractive index.

CONCLUSION

The result of Fizeau and Michelson Morley experiments led to the development of special theory of relativity. These experiments along with Hammar experimant repeated many times but always null results were obtained. All these experiments are conducted on the wave nature of light, but while interpreting the results the role of wavefront of light was completely ignored resulting in to wrong way. The results of Hammar experiment were also interpreted in the confirmation of special theory of relativity. The analysis submitted in the present article confirms the classical mechanics as well

REFERENCES

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